Exchange Rate Flexibility in China: Measurement, Regime Shifts and Driving Forces of Change

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Abstract

With an emphasis on government intervention that hinders market forces in currency movements, this paper presents a nuanced investigation of the degree and dynamics of flexibility in China's exchange rate regime. A high-frequency data model is developed to more accurately detect the extent to which the Chinese currency is market-driven. This indicator is then utilized in a Markov switching model to examine shifts in RMB regime flexibility. The results suggest a moderate increase in exchange rate flexibility since the 2005 reform. Additionally, two switching states are captured, and possible driving factors are discussed.

JEL Classification: C24; F31; F33

Keywords: Exchange Rate flexibility; Fear of floating; Exchange rate regime; Markov switching model; China

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1. Introduction

China's exchange rate policy has been the subject of much debate during the past decade. The early debate focused on whether the renminbi (RMB) was undervalued and the possible consequences thereof. More recently, however, discussions of the appropriate institutional arrangements for the Chinese currency have become prominent. A major aspect of the debate concerns the degree of flexibility of the Chinese exchange rate regime, which is the essential feature of exchange rate regime classification.

China maintained an exchange rate pegged to the US dollar from 1994 to 2005. Despite problems with an enduring, rigid dollar peg, some scholars maintain that China should continue the dollar peg because increased flexibility might result in deflation as it had in Japan (e.g., McKinnon, 2006, 2007; McKinnon and Schnabl, 2009, 2012). Arguing against continuation of the dollar peg, Roberts and Tyers (2003) demonstrate that in the face of external shocks, a flexible exchange rate regime would help China avoid the harmful consequences of a fixed exchange rate policy. For instance, it helps to reduce currency market speculation (Eichengreen, 2004, 2007). Both Obstfeld (2007) and Roubini (2007) contend that the large, modernized, diverse Chinese economy and eventual convertibility with open capital markets require exchange rate flexibility. Support for greater flexibility in China is also voiced by Bernanke (2005), Frankel (2005), Roubini and Setser (2005), Prasad *et al.* (2005), Goldstein and Lardy (2006), and Morrison and Labonte (2013), among others.

In response to international calls for change, the People’s Bank of China (PBOC), the Chinese central bank, announced in July 2005 the end of the dollar peg and a shift to a market-based, managed floating rate regime. A flexible mechanism is to be phased in by allowing the RMB to move within a narrow band around a central parity rate that is determined with reference to market makers’ opinions, movements of a basket of world currencies, and macroeconomic conditions. Although this experiment was disrupted in mid-2008 with the onset of the global financial crisis, in June 2010, the PBOC announced that it would "proceed further with reform of the RMB exchange rate regime and increase the RMB exchange rate flexibility."

China’s move to a more flexible exchange rate system, if completed, is significant because, as the second largest economy in the world, China has become increasingly important in international financial markets. However, China is internationally noted for intervening in the foreign exchange market, which causes the exchange rates to fail to reflect resource scarcity. The ensuing distortionary effects on international trade and capital movements are grave and are often cited as major contributing factors to global imbalances. While enhanced flexibility in China’s exchange rate regime may mitigate the effects of exchange rate misalignment, it might also indicate greater market orientation, which could be helpful in attaining a sound exchange rate policy over the long run. Furthermore, the market orientation of Chinese exchange rate policy also increases the likelihood that the RMB will become an international currency (Eichengreen, 2011).

Meanwhile, it is also well known that the reforms have been largely government administered when they do not always act on their public pronouncements.

In foreign exchange policy, this discrepancy is best known as fear of floating (Calvo and Reinhart, 2002), that is, countries who claim a floating exchange rate regime do not actually allow their currencies to fluctuate with changing economic conditions. Hence, a country's *de jure* exchange rate regime could be quite different from the *de facto* regime, a phenomenon that is widespread, particularly in the emerging markets. In this light, China's high profile reform announcements warrant careful examination (Eichengreen, 2007; Frankel, 2009). To detect the discrepancy between policy words and deeds, it is necessary and desirable to design a proper measure of exchange rate flexibility to gauge the *de facto* Chinese exchange rate regime and, hence, help us detect if fear of floating exists in China.

A good measure of exchange rate flexibility is also instrumental for capturing the evolution of a country's exchange rate regime because the selection of an exchange rate regime is a continuous process. Given that the degree of flexibility is the essential feature of an exchange rate arrangement, the regime that China operates during different periods may be defined in terms of the degree of flexibility, thus the flexibility index is also instrumental to improve our understanding of China's exchange rate regime selection process.

Earlier studies generally examine exchange rate flexibility in terms of the statistical property of nominal exchange rates (Lanyi and Suss, 1982; Barr, 1984). Recent research however puts an increasing emphasis on the indications of economic forces behind exchange rate changes, e.g. Girton and Roper (1977), Calvo and Reinhart (2002) and Levy Yeyati and Sturzenegger (2005), with one common feature as they are all monthly based. However, this may prevent them from producing more accurate results as the effects of intervention may be offset during the month. Thus, a higher frequency based method is very much needed. To this end, we marry the merits of the existing studies to construct a new flexibility index for RMB featuring the post-reform period. A market-oriented principle was closely followed in the sense that the flexibility index is designed to provide a plausible estimate of the extent to which the Chinese government allows the RMB to be driven by market forces.

To build the daily flexibility index, we utilize exchange rate data from the largest Chinese commercial bank dealing in foreign exchange (Bank of China) and the New York Federal Reserve. The results suggest that there were sizable increases in flexibility immediately after the reform announcement; however, this process was disrupted when the adverse effects of the global financial crisis emerged in mid-2008. The PBOC quietly re-pegged the RMB to the dollar, and the flexibility index consequently dropped dramatically, indicating that Chinese intervention thwarted the market forces driving the exchange rate. This low-flexibility policy was enforced until

March 2010, when the central bank announced the re-institution of exchange rate reform.

We then examine China's exchange rate policy by investigating changes in the flexibility of the RMB exchange rate in a regime switching setting. This newly constructed daily flexibility indicator is applied in a Markov switching model to examine whether and when there are regime breaks in the RMB exchange rate flexibility. The results obtained through the Markov switching model suggest that the dynamics of RMB flexibility have passed through two distinct switching states wherein the parameters of the high- and low-flexibility states differ noticeably. The timing of these regime shifts provides evidence of fear of floating in China. For the sample period as a whole, the degree of RMB flexibility in China is relatively low despite the reforms, reflecting the gradual pace of China's transition to a floating exchange rate system. Overall, the Chinese government still exerts considerable control over the foreign exchange market, whereas China is edging towards greater exchange rate flexibility, especially in the wake of the global financial crisis.

The remainder of this paper is organized as follows. Section 2 is devoted to the construction and analysis of a new exchange rate flexibility index. Section 3 examines structural changes in the Chinese exchange rate regime through a Markov switching model. Section 4 provides summary and concluding remarks.

2. Measuring Flexibility: A High Frequency Model

Prior Studies

Earlier studies generally view exchange rate flexibility on the basis of the statistical properties of nominal exchange rates, such as variance, standard deviations, (Lanyi and Suss, 1982; Barr, 1984). Important improvements lately emerge to take into account indications of the economic influences that underlie exchange rate movements. On an absolute basis, a large scale of exchange rate movements, or high exchange rate volatility, alone is a symbol of high flexibility. However, on a relative basis, this claim is supported only when there is sizable pressure on that currency during the time period. The idea of 'relative fashion' is particularly emphasized in recent studies. For instance, Calvo and Reinhart (2002) propose a variance ratio index constructed to capture variation in the exchange rate relative to policy instruments. Levy-Yeyati and Sturzenegger (2005) build a flexibility indicator utilizing the volatilities of exchange rates and foreign reserves.

Another strand of the flexibility literature builds on the concept of EMP, i.e. the exchange market pressure; its models are accordingly referred to as EMP-based models.[1] EMP can be utilized to assess the proportion of the pressure that is mitigated by movements in the exchange rate alone. These studies have usually assumed that the greater the pressure alleviation, the more flexible is the regime. In addition to using EMP in the ratio analysis, an alternative approach is to deploy EMP directly in the econometric estimation of the degree of exchange rate flexibility. Studies in this group mainly follow the pioneering work of Frankel and Wei (1994). However, scholars have different views about how EMP series should be constructed and the effectiveness of the proxies used. For example, Willet *et al.* (2012) point out that not all changes in foreign reserves, which is generally used as a key building block of EMP, are government interventions and sometimes official interventions are 'leaning with the wind' which involves no reserve changes.

The models discussed above can generate a time series of flexibility index, which provides a useful summary of the evolving nature of a country's exchange rate system. They also enable a look into indications of the economic influences including government policy that underlie exchange rate movements, or the lack thereof.

Nevertheless, these models suffer from a common drawback, that is, the reliance on monthly data to compute the flexibility indexes. Such dependency is problematic because government intervention is usually conducted in a higher frequency, e.g. daily. Accordingly, monthly average data may camouflage the frequency and effects of government intervention. To overcome this problem, we develop a high-frequency approach based on daily data to measure exchange rate flexibility.

High Frequency Flexibility Indexes: Construction

In China, foreign exchange transactions are administered by the Chinese Foreign Exchange Trading System (CFETS), which is a computerized national network that publishes the central parity rate (CPR) of the RMB against the US dollar at 9:15 AM (Beijing time) each business day. The CPR rate, which is set by the Chinese central bank, considers three influences: the individual rates offered by official market makers, international currency movements and macroeconomic conditions. Because this rate-setting process is led by the Chinese central bank, the CPR is considered as the official exchange rate, which then provides a benchmark rate for the Chinese foreign exchange system. The rate-setting process also reveals the fact that exchange rate rigidity in China is often the result of government control that shadows the influence of market forces and therefore, it is necessary and appropriate to define the flexibility of exchange rate in terms of the extent to which a monetary authority allows the market to influence the price of the country's currency in the foreign exchange market.

In this paper, by comparing the variability of this official rate with the market rate, a gap could be revealed, which may serve as a measure indicating government intervention in the currency movements.[2] Through this, one may gauge the extent to which the RMB is allowed to move in line with supply and demand forces. After searching for a proxy that reflects the market, we selected a market rate series for the RMB/USD that is published by the Federal Reserve Bank of New York (Federal

Reserve or FED hereafter), which uses data from a sample of market participants. These data are the noon buying rates of the RMB against the US dollar in New York on business days for cable transfers payable in foreign currencies. This series can provide useful information for our research because it is highly unlikely that the Chinese government can control the exchange rate in New York.

However, by its nature the official central parity rate tends to be of low variability, which limits the indicative accuracy of the changeability differential between this rate and the market rate as a flexibility index.[3] This prompts us to search for a domestic exchange rate whose variability can be meaningfully compared to that of the RMB exchange rates in New York.

We choose the exchange rate quoted by the Bank of China (BOC) because it is the earliest and the largest player in the foreign exchange market in China and its rate series is representative of the rates offered by commercial banks in China.[4] It is important to note that Chinese trading rules require commercial banks to conduct their market transactions based on the CPR, and the quoted rates must be within a government-specified band, which was initially +/- 3‰ and has recently expanded to +/- 2% around the central parity rate.[5] So the BOC exchange rates are in fact semi-controlled. However, with the development of China's financial reforms, the BOC increasingly has its own commercial interests and its rates become gradually more driven by market influences. As such, comparing the variability of this semigovernment influenced rate to that of the Federal Reserve rate may provide useful information on the extent of RMB flexibility.

Use of the ratio may have another advantage over the other competing methods. It is well known that currency prices are influenced by common international factors or events despite its own characteristics. In this light, the volatility ratio helps to analyse the relative strength of market forces transmitting to the movements of the RMB exchange rates, which coincidences with the essence of our definition of the currency flexibility measure.Based on these comparisons, we then estimate the high-frequency model to produce flexibility indicators for the RMB. The procedure involves the following steps (refer to Eq.1). First, we calculate the standard deviation of returns of the RMB/USD rates from the BOC (BOC rates) in the last 21 business days (including the current business day)[6] to proxy exchange rate volatility of the current business day. Next, the daily relative volatility ratio is obtained by dividing the volatility of the BOC exchange rates by that of the market-based exchange rates.

Finally, to index these ratios, we take the base as of January 4, 2006 when the central parity rate was officially installed. This means that the value of the flexibility ratio on that day is made to be 100, and the reference base is then applied to every daily flexibility ratio in the series:

$$\text{Flexibility Index}=100*\frac{\text{Relative Volatility Ratio}}{\text{Reference Base}} \quad (1)$$

Because the pegged RMB/USD exchange rate is upheld before July 21, 2005, the rolling calculation of the daily flexibility index begins on July 22, 2005, the first business day after the reform was announced, and ends on March 29, 2013, the latest day in our sample period. We denote the computed daily index of RMB flexibility as BOC_FED and plot the series in the following figure, while the black line represents the mean flexibility value as 115.3.

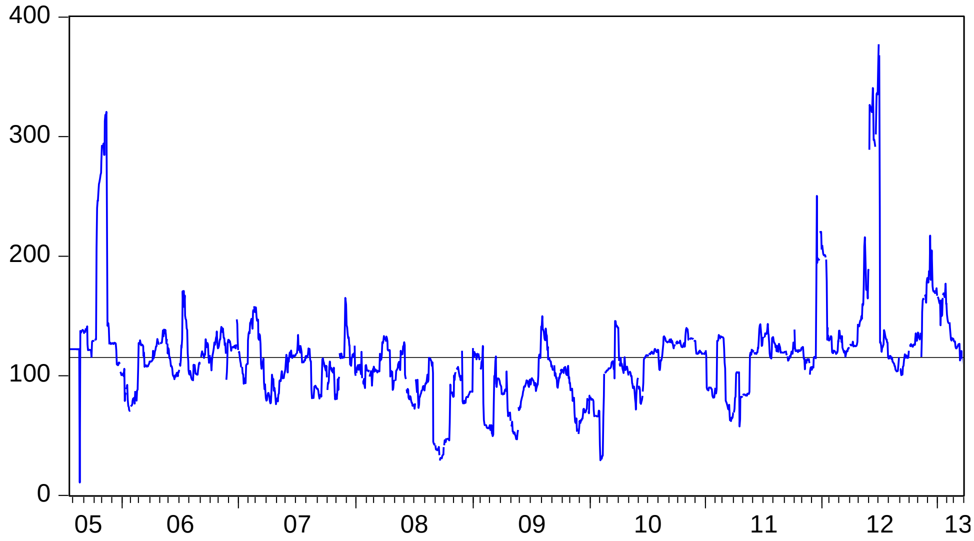


Figure 1. The Exchange Rate Flexibility of RMB

It is clearly seen from the figure that the index has its ups and downs during the sample period, which confirms previous findings that the RMB flexibility was enhanced after the reforms, but the process was disrupted by the outbreak of two crises. For instance, starting from mid-2008 until the second reform announcement, the flexibility index was hardly seen beating its mean value, suggesting the Chinese authority tightened exchange rate control when it feared that the global financial crisis posed a threat to the export sector. A similar decrease was also captured when the

European sovereign debt crisis emerged. However this time the low flexibility phase did not last long.

In addition to confirming the commonly held market perceptions, our high-frequency data model offers richer information about currency flexibility in China. For example, since the 2005 reform China's exchange rate management has been subject to several changes. Under the regime currently in place, the Chinese monetary authorities mainly deploy two tools to prevent or restrict undesirable fluctuations in the exchange rate: one is the government controlled central parity rate and the other is the band in which the RMB rate is allowed to fluctuate in the marketplace. Initially, the central parity rate was based on the previous day's closing price. This practice would continue the momentum of previous exchange rate changes such that cumulative exchange rate variation and level changes could be quite sizable. Fearing rapid appreciation of the exchange rate and increasing variation, the government changed this pricing rule on January 4, 2006 and reset the central parity rate on the opening of every business day rather than simply using previous day's closing rate.[7] As a result, though the BOC_FED index exhibits a surge after the reform[8], it sharply decreased in January 2006. These developments are well captured by the behavior of the high frequency data flexibility indexes.

The fact that the two exchange rates are drawn from different markets may prompt some doubts on the role played by capital control policies, as it is widely held that Chinese authority has adopted tight control on the capital flows, which largely disrupted the link between onshore and offshore markets. Therefore, some may argue that the volatility difference in the two exchange rate series should be considered as a measure of capital control intensity rather than an exchange rate flexibility as we discussed above.

While we do acknowledge that there is some effect of capital control on the exchange rates from a theoretical perspective, the *de facto* intensity of this impact is however much in question empirically. Aizenman and Sengupta (2013) find that capital account openness plays no significant role in China's trilemma configurations[9], which confirms a widely held view that the effects of China's capital controls are not omniscient, but are decaying off over time. In fact, arbitrage between China and rest of the world is not entirely impossible and may be prevailing at some point (Ma and McCauley 2008, Galati *et al.* 2007). Yu (2008) notes that a large portion of China's large trade surplus is nothing but hot money in disguise, aimed at evading capital controls. Similar doubts have also been raised on the FDI inflows. Moreover, compared to the changing volatility ratio index , it is worthy to point out that the Chinese authority does not change its stance on the capital control very often, the fact of which is clearly evident from the annual IMF report for the time period in consideration.

Though we cannot fully rule out the impact of capital controls on our index, it is important to note that exchange rate flexibility is defined here as the extent to which the authority allows the market forces to impact the price of RMB, treating all forms of control policies equal, which include but are not limited to the direct sell (or purchase) in the FX market, ‘window guidance’, and the capital control policies as well. Put in other words, we are more interested in the end-product of the ‘managed’ floating rate system that China adopts but do not really differentiate the specific ‘intervention’ form at the other end.

While it seems not appropriate to use our volatility difference to proxy the intensity of capital controls, it is important to note that exchange rates is one of the many economic factors that are impacted by the capital control policies, which in turn makes it possible to build alternative measure of the intensity of capital controls. In fact, there have been a few well known models in the literature, such as Edison and Warnock (2003), Chinn and Ito (2008).

The companying EMP

In light of the recent exchange rate flexibility models, it seems plausible to double-check the usefulness of our flexibility index by looking at the companying EMP.

To this end, we follow Klaasen and Jager’s (2011) method in calculating a daily-based measurement of EMP. Compared to the other popular approaches, Klaasen and Jager’s (2011) method stands out as this measure is consistent with the very definition of EMP and does not rely on any exchange rate model. Another crucial feature of their method is that the measure is consistent across frequencies. Thus, it is straightforward to aggregate the daily EMPs to obtain a monthly measure.

In Klaasen and Jager's (2011) study, the specific form of EMP is written as follows,

$$EMP_t = \Delta S_t + w_i(i_t - i_t^d) + w_c c_t \quad (2)$$

where ΔS_t is the nominal exchange rate change at time t, defined as the domestic currency price (RMB) of one unit of foreign currency (USD); i_t is the domestic interest rate; i_t^d stands for the interest rate level if exchange rate objective is not a determinant. As shown in Klaasen and Jager (2011), i_t^d can be reasonably simplified by using the foreign interest rate level as the proxy; w_i is the weight of relative interest rate level $(i_t - i_t^d)$ and w_c is the weight of the scaled intervention.

We use the overnight interest rate from PBOC and Federal Reserve to represent the interest rate level in China and the US respectively. The weights of w_i and w_c are set equal to the standard deviation of the nominal exchange rate changes to that of the interest rate and the scaled intervention component.

As discussed above, the change of foreign reserve might not serve as a perfect proxy for exchange rate intervention. Hence, to better proxy the unobservable central bank intervention, we make use of one unique statistic from the PBOC, called 'funds outstanding for foreign exchange'. It can be considered as the result of intervention as it mirrors the purchase of foreign assets. To make it more comparable, the level of ‘funds outstanding for foreign exchange’ is scaled down by the preceding domestic M1. The data for M1 and ‘funds outstanding for foreign reserve’ is collected from PBOC. However, as they are only available in monthly frequency, we apply the cubic interpolation method to transform them into a daily–based series[10].

Similar to the flexibility index, the EMP series is calculated from July 22, 2005 to March 29, 2013, and the result is plotted in the following figure.

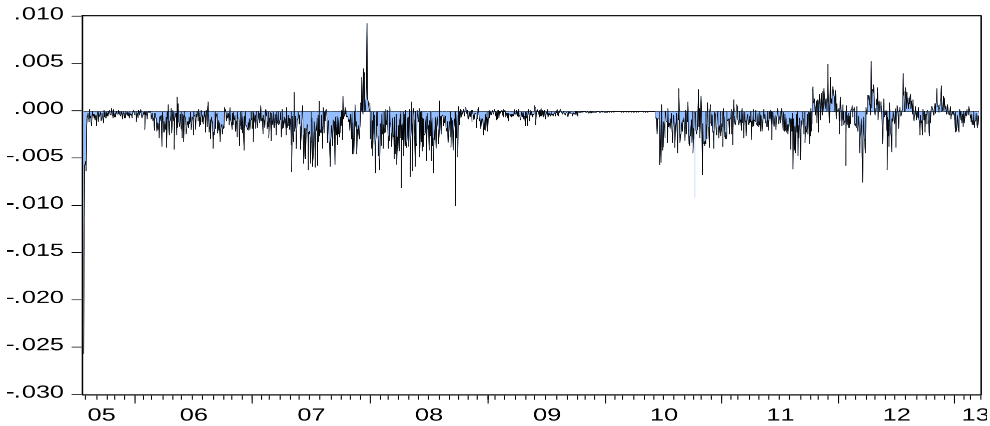


Figure 2. Exchange Market Pressure of RMB

It is clear from the above figure that there was an appreciation pressure, i.e. a negative EMP, on the RMB during most of the sample period. In contrast to policy maker’s intentions, following the 2005 reform, the appreciation pressure exaggerated sharply rather than being alleviated, which reflects the prevailing market perception that a consistent appreciation of RMB was on its way. A negative EMP was maintained until December 2007 when the market panicked about the looming crisis. However, the market quickly reversed its course by recognizing that the outlook for China’s growth was strong and the RMB was still undervalued. Nevertheless, it is observed that from mid-2008 to mid-2010, the EMP was close to zero, i.e. indicating relatively low appreciation pressure on the RMB. Following the second reform announcement, the EMP quickly decreased. Since then it has several brief reversals as a result of prevailing market conditions.

As discussed above, existing studies have emphasized that high volatility, or a relatively high volatility ratio, does not necessarily mean the currency is truly flexible. It is necessary to take into account the prevailing pressures. The degree of flexibility of one currency is only warranted when there is a considerable level of exchange market pressure overhang. Hence, we may visually compare the patterns observed in the two figures to check if our flexibility index makes sense.

On one hand, during the crisis period, even though there was little pressure on the RMB, the flexibility index was in a ‘low’ phase, which supports the claim that reform was halted by the Chinese authority and the RMB was not flexible. On the other hand, in non-crisis periods, the striking difference in the flexibility index may help to locate ‘high’ flexibility phases. Notwithstanding the considerable pressure at the time, the several surges of the flexibility index clearly indicate that RMB was actually variable, though those periods seem to be rather short-lived. In summary, it seems safe to say that the effectiveness of our flexibility index is warranted and RMB has undergone several different flexibility phases, revealing more ‘hidden’ dynamics than those suggested by existing studies.

3. *De Facto* Regime Switches and Fear of Floating in China

Sudden changes in government policy may induce drastic breaks in the behavior of economic variables (Hamilton, 1989; Sims and Zha, 2006). Such breaks often mean the typical behavior of a variable switches to a very different one, and hence may generate fundamental repercussions. China's exchange rate policy is a case in point. During the sample period the Chinese authorities have initialed two rounds of reforms of the exchange rate system, allowing greater room for market forces to influence the RMB price, including that against the US dollar. This implies that, during the period under examination the RMB rate switched from a pegged to a managed flexible rate regime, and back and forward twice. During this period, the behavior of the RMB rate and the property of China's exchange rate system had both exhibited distinct patterns.

Given the importance of regime switches, researchers logically would like to detect the regime changes as they happen so that they may find out the implications of the regime break and to design suitable responses accordingly. However, it is unrealistic to expect a single, linear model to characterize all the distinct behaviors of the variables in different regimes. In contrast, the Markov regime switching (MRS) models prove appropriate in capturing more complex dynamic patterns of the variables in question.

The Markov regime switching models have found wide applications in economics and finance (Ang and Timmermann, 2012). Among the pioneering studies, Hamilton (1989) applies the MRS model to research into the US business cycle. Many papers applying the methodology then follow suit. Recent studies have also deployed the MRS models to explain exchange rate behavior, e.g. Engle and Hamilton (1990), Engle (1994), Bollen *et al.* (2000), Bergman and Hansson (2005), Ichiue and Koyama (2011).

For our research interests, in addition to capture regime changes in the Chinese exchange rate policy, the Markov switching model has another helpful property; it allows the detection of the timing of regime shifts, which would help to resolve the problem noted by Frankel and Xie (2010) and identify proper 'break-points' to differentiate sub-periods. Furthermore, analysis of the regime shifts can help us achieve a better understanding of a critical attribute of the Chinese exchange rate regime. Exemplified by fear of floating, studies have pointed out that countries do not always conform to their public announcements, i.e. there is considerable differences between policy announcement and its implementation. As one key objective of this paper is to find out exactly when the policy shift starts to impact the behavior of the RMB/USD exchange rate, we cannot solely rely on the *de jure* dates.

By detecting the timing of RMB's regime shift, the Markov model would help capture the critical features of China's exchange rate policy in a time of economic transition.

Given the findings in the previous section, we assume that there have been two flexibility regimes, i.e. a high-flexibility regime and a low-flexibility regime. As the flexibility is built on the standard deviation of exchange rates, we only need to use the mean (constant) coefficient to differentiate these two regimes while the variance parameter is assumed to be non-switching. Also, to take account the common dependence of the second moments of the exchange rates, we include an AR(1) term in our model. Accordingly, the Markov switching model could be written as follows and we report the estimation results in Table 1.[11]

$$Fle\_Index_t = \mu(\mathrm{s}_t) + \phi_i(Fle\_Index_{t-1} - \mu(\mathrm{s}_{t-1})) + \varepsilon_t \qquad (3)$$

where Fle_Index_t is the BOC_FED flexibility index at time t. It is conditional on an unobservable variable s_t, which has two possible values: $s_t = 1$ (Low-flexibility) and $s_t = 2$ (High-flexibility); μ denotes the mean parameter depending on the regime at time t which is assumed to be changeable in those two states; ε_t is the error term, following the usual iid assumption.

Table 1. Markov Regime Switching Results of Flexibility Index

Panel A	Regime Varying Coefficients	
	Regime 1	**Regime2**
Constant	85 (5.53***)	155 (10.09***)
	Regime Invariant Coefficients	
AR(1)	0.99 (267.88***)	
Log (SIGMA)	2.06 (123.20***)	
Log Likelihood	-6354.92	

Panel B	Constant Transition Probabilities P(i,k)=P(s(t)=k|s(t-1)=i	
	P(1,1)=99.1%	P(2,1)=0.8%
	P(1,2)=0.9%	P(2,2)=99.2%
	Constant Expected Durations (Days)	
Regime 1	125.9	
Regime 2	114.4	
	Transition Matrix Parameters	

P11-C	4.83 (13.36 ***)
P21-C	-4.73 (-13.05***)

*Notes: This table presents the results of the two-state Markov switching model of the BOC_FED flexibility index. In Panel A, we report the estimated coefficients for the regime-varying and regime-invariant variables, with the corresponding z-statistics in parentheses. Panel B reports the constant transition probabilities between the two regimes, the expected duration for each regime, and the transition matrix parameters. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.*

Several interesting results emerge from the estimation of the MRS model. Firstly, it helps us to formally test regime switches in the flexibility index that we construct. We make use of a likelihood ratio (LR) test proposed by Garcia and Perron (1996). The null hypothesis is there is no regime shifts (the flexibility index is better reproduced by a linear autoregressive model) against the alternative of the presence of regime switches (the flexibility index is better accounted by the MRS model). The LR is calculated as follows:

$$LR = 2 * |\ln \mathrm{L}_{MRS} - \ln \mathrm{L}_{AR}| \quad (4)$$

where $\ln L_{MRS}$ and $\ln L_{AR}$ denote the log likelihood of the MRS and the linear autoregressive model, respectively. As shown in Table 2, the LR test statistic is highly significant at the 1% significance level. Based on Davies (1987) critical values, we reject the null and confirm the regime shifts in RMB flexibility.

Table 2. LR Test Results

$\ln \mathrm{L}_{MRS}$	$\ln \mathrm{L}_{AR}$	LR
-6354.92	**-6721.50**	**736.16*****

*Notes: Similar to the estimated MRS model, the linear model has an order of one autoregressive term. *** indicates significance at 1% level.*

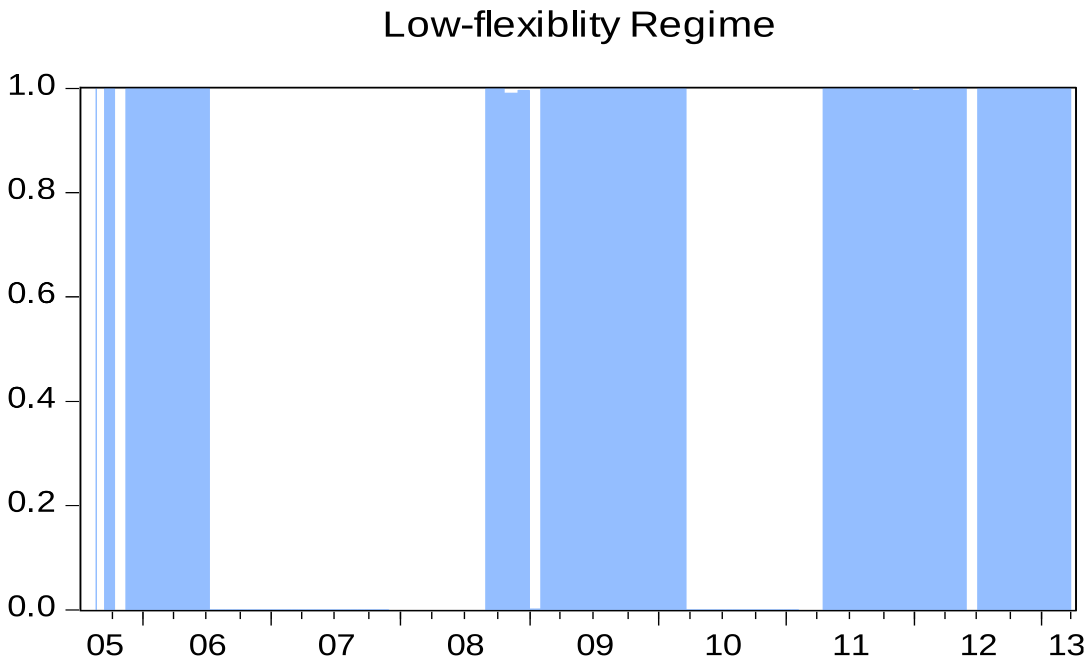
Secondly, we provide evidence that the exchange rate flexibility index varies markedly between the two regimes. In the low-flexibility state, the coefficient on the constant reads 85 and in the high-flexibility state it is shown to be 155. The adoption of a managed floating rate regime has helped the RMB achieve an increase in flexibility. Of 1805 observation days, 855 days (approximately 47.4%) are in the high-flexibility state though mostly in the period before the 2008 global financial crisis.

In contrast to the sharp difference in the mean coefficient, both regimes show high regime dependence: it almost has a probability of one to stay in the same regime. Moreover, there is little difference in the length of the expected duration of each regime. The low-flexibility state reports an expected duration of 125.9 days while the expected duration of the high-flexibility is only 11 days shorter.

Thirdly, we plot the estimated smooth regime probabilities to see when the regime switches take place. Though the figure is quite self-explanatory, we report the estimated ‘starting’ and ‘ending’ dates of the ‘high-flexibility’ regime in the Table 3. The first thing worthy to note is that it confirms the switches that were generally presumed by the market. For instance, in the face of the worst financial crisis since the Great Depression of the 1930s, China took a cautious stance towards policy responses, including exchange rate arrangements. The RMB exchange rate was kept inflexible during the global financial crisis period. However, the MRS model report different starting and ending dates for the ‘crisis period’. According to the documented dates in Table 3, the ‘high-flexibility’ regime was ended on 25 August 2008 and resumed on 23 March 2010, while the official resumption of the reform was announced on 19 June, 2010, suggesting the *de facto* regime switch did occur a little earlier.[12]

Secondly, the MRS model reveals more shifts of the RMB flexibility which may otherwise remain ‘hidden’. In the case where monetary authorities do not publicly announce its intervention operations, we follow studies such as Beine *et al.* (2009), Gnabo *et al.* (2009), and Dewachter *et al.* (2014) to make use of Factiva to double-check the results from the MRS model. Through search we obtain daily Reuters reports on information of the spot foreign exchange market including media analysis of the Chinese RMB/ US dollar and other related news. It proves particularly useful of some traders’ comments connotative of possible intervention by the Chinese monetary authorities. These international reports are usually reliable and often helpful for one to identify the ‘surprising’ points relating to the shift of China’s policy regime. For all those ‘break points’ that we can identify as the dates when the RMB shifted out of the ‘high flexibility’ regime, we could find corresponding reports made by traders indicating that there was a high chance that the PBOC had intervened on the dates. For instance, the first shift to the ‘low flexibility’ regime is estimated to occur on 13 September, 2005. On that day, the Reuters reported that one trader explicitly commented that the PBOC was very likely to have intervened as no one else would buy the US dollars under the prevailing market conditions. On the other hand, while traders also reported occasions of possible Chinese intervention in the ‘high flexibility’ period, the frequency of such occasions is much less than in the ‘low flexibility’ period.

In summary, the estimated dates give sound evidence of fear of floating in China. This also suggests that China’s move to greater RMB flexibility is not a one-off event. Rather, it is a process where the *de facto* regime switching occurs in a gradual manner.



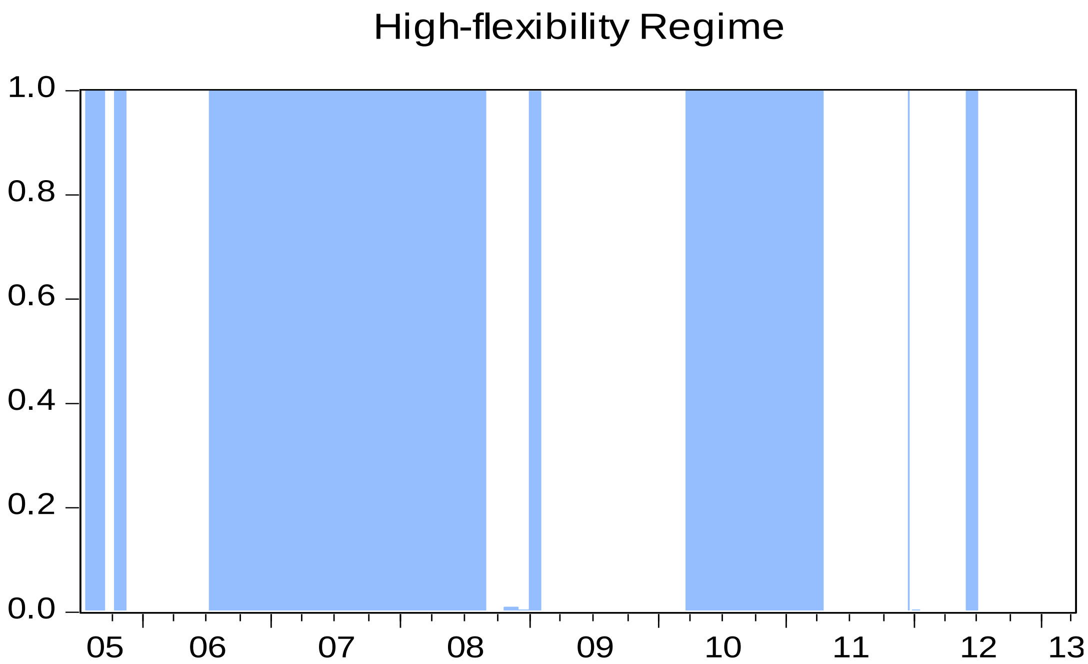


Figure 3. Smooth Regime Probabilities

Table 3. The Estimated Starting and Ending dates of the 'High-flexibility' Regime

	Starting Date	Ending Dates
1	25 July 2005	12 September 2005
2	17 October 2005	15 November 2005
3	13 July 2006	25 August 2008
4	31 December 2008	9 February 2009
5	23 March 2010	20 April 2011
6	5 June 2012	5 July 2012

Notes: The reported dates are based on the smoothed regime probabilities, estimated from a two-state Markov switching model of the BOC_FED flexibility index.

Possible Driving Forces

For possible drivers of the regime switching of exchange rate flexibility, there is currently no consensus in the literature. Here we choose to look into three variables that may plausibly affect the dynamics of the exchange rate regime switching. The first candidate is the interest rate differential between China and the US, which has been persistent and largely in China's favor over the sample period. It is noticed that there is much coverage in both literature and news that the interest rate differential has induced arbitrage from international investors, which is further fueled by a one-way betting on RMB appreciation. Jongen *et al.* (2012) and Spronk *et al.* (2013) have shown that the level of interest rate differential plays an important role in determining trading strategies in the forex market, which ultimately leads to volatility. Hence, given a higher interest rate differential we would expect to see higher exchange rate volatility, which implies a positive relation between the interest rate differential and the flexibility index. However, this impact may be dampened by the interventionist policy as it pushes the authorities to respond more aggressively when there is a higher interest rate differential. Therefore, we only hypothesize that the coefficient of interest rate differential displays a regime switching behavior, without specifying the sign of the relation.

The second candidate is the EMP, which is included here for two reasons. On one hand, recent studies, such as Frankel and Xie (2010), have used EMP as an explanatory variable in econometric estimation to investigate to what extent exchange rate flexibility is affected by currency pressures. On the other hand, EMP provides a summary indicator of various underlying factors. Aizenman *et al.* (2012), Aizenman and Pasricha (2012) and Feldkircher *et al.* (2014) have all proposed possible determinants of the exchange market pressure. However those variables are only measured at a relatively low frequency, such as monthly, quarterly or even annually. Intuitively, the interventionist policy predicts a negative relation between EMP and the flexibility index as the surge of currency pressure would motivate the authorities to smooth exchange rate movements. However, in the 'high flexibility' regime, it seems plausible to expect that the central bank may refrain itself from doing so or make little response to the pressure. Nevertheless, given the fact that the EMP series changes sign during the sample period, we do not put constraint on the sign of the relation *ex ante* but only hypothesize that the flexibility index will respond asymmetrically to EMP in the two regimes.

The third explanatory variable that we consider is sovereign risk perceived by investors regarding the Chinese economy. To this end, we make use of the CDS spread.[13] During most of the sample period under examination, the CDS index is quite stable and at a relatively low level. The two drastic increases coincided with the two major economic shocks, i.e. the global financial crisis and the European sovereign debt crisis. Therefore, it closely tracks the markets' perception on the expected performance of the Chinese economy. Different from the previous two variables, the CDS spread is used as an exogenous variable in our model to account for the transition probabilities between regimes. Specifically, we hypothesize a negative association between the CDS spread and the RMB flexibility index as a higher CDS spread would result in a shift out of the high flexibility state.

The estimated MRS model could be written as in Equation 5,

$$Fle\_Index_t = \mu(\mathrm{s}_t) + \phi_i(Fle\_Index_{t-1} - \mu(\mathrm{s}_{t-1})) + \sum_{j=1}^{3}\beta_j Z_{j,t-1} + \varepsilon_t \qquad (5)$$

where all the variables are defined identically as in the previous estimation. The only exception is that we use Z to represent the three possible explanatory variables. The estimation results are reported in Table 4.

The results generally support our hypotheses regarding the three candidate explanatory variables. Firstly, the interest rate differential reports a positive impact on the flexibility in both regimes, indicating that during the sample period the interest rate differential contributed to the increase of the exchange rate volatility, possibly through arbitrage activities. Moreover, the higher coefficient reported from the low flexibility regime seems to suggest the impact from the interest rate differential and the central bank intervention are both larger in amplitude, though the aggregate effect is still positive. However, it is worthy to note that the coefficients in both regimes are not statistically significant.

Secondly, it is reported that EMP has a negative effect on the flexibility in both regimes, which might be reconciled with the fact that the Chinese authorities have displayed a cautious, maybe over-cautious, approach in preceding the reform. The presence of exchange market pressure on the Chinese currency tends to lead to a decrease in the authorities' willingness in increasing the flexibility of the RMB. What is more important is that the results confirmed our hypothesis that the flexibility index would respond asymmetrically to EMP: compared to the high-flexibility regime, the BOC_FED index responded more dramatically, nearly 18 times of the magnitude of the effect, in the low-flexibility regime.

Thirdly, the results imply that the CDS may serve as an early warning signal of regime shifts as a higher risk spread lowers the probability of staying in the high-flexibility state. However, the magnitude of this effect tends to be very limited.

Moreover, the high regime dependence once again highlights the fact that the Chinese authority still firmly controls the pace of the reform process, or the degree of RMB exchange rate flexibility.

Table 4. Markov Switching Model with Time-Varying Transition Probability

Panel A	Regime Varying Coefficients	
	Regime 1	**Regime2**
Constant	84.3 (5.60***)	154.4 (10.23***)
Int_Diff(-1)	0.40 (0.95)	0.19 (0.31)
EMP(-1)	-5.13 (-2.45**)	-0.29 (-0.47)
	Regime Invariant Coefficients	
AR(1)	0.99 (265.86***)	
Log (SIGMA)	2.05 (122.86***)	
Log Likelihood	-6347.00	

Panel B	Time-varying Transition Probabilities P(i,k)=P(s(t)=k|s(t-1)=i	
	P(1,1)=99.2%	P(2,1)=1.2%
	P(1,2)=0.8%	P(2,2)=98.8%
	Time Varying Expected Durations (Days)	
Regime 1	127.4 (1.4)	
Regime 2	121.3 (44.6)	
	Transition Matrix Parameters	
P11-C	4.85 (13.30***)	
P11-CDS_1YR(-1)	0.02 (-0.81)	
P21-C	-5.25 (-10.44***)	
P21-CDS_1YR(-1)	0.017 (2.05**)	

*Notes: This table presents the results of the two-state Markov switching model of the BOC_FED flexibility index. It is different from Table 1 because the transition probability is assumed to be time varying and dependent on CDS. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.*

4. Conclusions

This paper investigates the behavior and dynamics of flexibility of the Chinese exchange rate regime since 2005 when the reform was launched to lift the RMB's dollar peg and to phase in a managed floating rate system. Defining currency flexibility as the degree of exchange rate variation in a relative term, this research examines the extent to which government control have hampered adjustment of the RMB exchange rate. Monthly data models prove inadequate for this task since government intervention rarely lasts months and an intervention's effects may be offset within the month. We focus on the result of government control, i.e. the market exchange rates, and develop flexibility measures based on the daily data. It represents a nuanced approach to measuring exchange rate flexibility and yields richer information about evolving trait of China's exchange rate regime.

A Markov switching model with two states is then estimated utilizing the newly built daily flexibility index. The parameters in the high- and low-flexibility states differ noticeably for the RMB. In detecting the timing of regime shifts, we observe evidence of fear of floating in China. This empirical investigation also sheds lights on the possible drivers of the RMB flexibility in different states. The interest rate differential seems to have a positive effect on the RMB flexibility in both regimes, though the coefficients are not statistically significant. Even though EMP has a negative effect on the RMB flexibility in both regimes, the magnitude of the effect decreased drastically from the low-flexibility regime to the high-flexibility regime.

We also find that the CDS index, which indicates the risk that China is exposed to, may serve as an early warning signal for regime shifts of RMB flexibility since a higher risk spread lowers the probability of RMB staying in the high-flexibility state. Last, while there is evidence of fear of floating in China, it is also true that the RMB is making inroads into the problem of lacking flexibility in the exchange rate regime. The pace of China's transition to a managed floating rate system is still slow and the government control over the foreign exchange market remains considerable. However, the flexibility enhancing process has already started. Along with the country's growing economic and financial might, the cumulative effect of this process on international finance could be radical.

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[1] EMP is an acronym for Exchange Market Pressure. First developed by Girton and Roper (1977), this concept has been extended and popularized significantly by scholars, including Roper and Turnovsky (1980), Weymark (1997), Eichengreen *et al.* (1995) and Klaassen and Jager (2011).

[2] It would be straightforward to deploy official intervention data to calculate the flexibility index. However, no publication of such data in China and some proxies have to be chosen. The usual proxy for intervention, i.e. changes in foreign reserves is not directly feasible in the Chinese context since reserve changes are usually reported in China at low frequency and their changes are often caused by a variety of reasons, not necessarily by intervention. Empirically, given the property of time series of reserves data, no reliable method can be applied to derive sound daily interpolation. In this light, we choose to rely on the information revealed by the exchange rates.

[3] We thank an anonymous referee for pointing out this issue.

[4] The BOC rate is from Bank of China, available in DataStream by 16:15 (GMT) on each business day.

[5] The fluctuation band was officially announced on July 21, 2005 to be +/- 0.03% around the central parity. This was raised to +/- 0.05% from May 21, 2007. From April 16, 2012, the band was expanded to +/- 1% and on March 17, 2014 it became +/- 2%.

[6] We choose 21 days because there are approximately 21 working days in a calendar month. We have also tried 10 days and 60 days, the results show no significant difference.

[7] This policy was re-instituted on 11 August 2015 as the PBOC latest effort to improve the central parity rate-setting process.

[8] Our results show that the first dramatic increase of the flexibility index occurred around October 2005, not immediately after the reform date. However, it simply suggests that the Chinese authority has proceeded the reform cautiously and it reinforces the fact that our index could offer more information.

[9] The much celebrated 'Trilemma' theory states that an open economy at any time may only simultaneously choose two out of three potentially desirable objectives: namely the autonomy in conducting monetary policy, stable exchange rates and internationally free capital movements. Though it was first proposed in the 1960s, the existence of the 'trade-off' has gone through arduous verification, including some recent studies by Aizenman and his co-authors.

[10] To check the robustness of our daily-based EMP, we've calculated the monthly EMP for RMB for the sample period using other popular methods, including Weymark (1997), Stavarek (2007). We find the results have a high positive correlation with the monthly aggregated EMP using the Klaassen and Jager's (2011) method. We have scaled up the results 100 times to make it more compatible to other variables in the following estimation.

[11] A common estimation procedure is followed in this study and hence the detailed technical description was left out. Interested readers can find such information easily in all the aforementioned studies. Hamilton (2008) gives excellent review for the MRS model.

[12] Through Factiva, we find that on 7 April 2010, the headline news was that in the meeting soon to be held between the presidents of China and the USA, the RMB exchange rate would be a major issue to be discussed. On the following day, 8 April 2010, there was news that China would soon announce a change to its then exchange rate regime.

[13] The CDS data are sourced from Bloomberg.